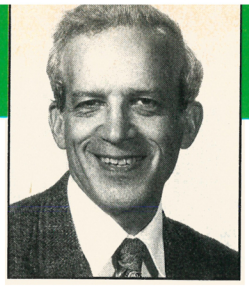


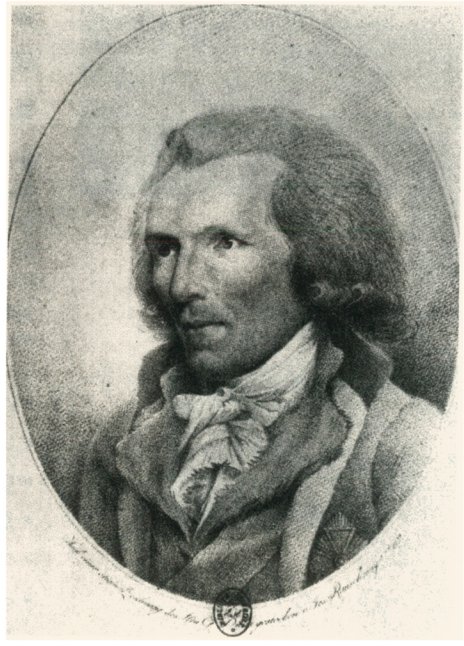
ABOUT BENJAMIN THOMPSON

Daniel Kleppner

Technology transfer, education, energy and the environment are high on this year's list of political buzzwords. For a politician to talk about these matters is to demonstrate his or her willingness to grapple with some of the great issues of the day. To actually improve the situation is quite another matter. Two hundred years ago, however, a character by the name of Benjamin Thompson not only thought deeply about these issues but pursued research and implemented programs that were often successful.

Benjamin Thompson is not a household name, though it deserves to be, for we are in debt to him for many of our domestic comforts. Central heating, the smokeless chimney, the kitchen oven and range, the double boiler, the pressure cooker, the drip coffeepot, thermal underwear—the list goes on. Using differential photometers and radiometers of his own invention he elevated lighting and heating design into quantitative subjects. His many inventions revolutionized household life, though they all remained unpatented because he viewed patents as fundamentally selfish. In addition to being one of the greatest applied scientists of all time, Thompson was a social engineer who could transform an ignorant and vicious crowd into a group of tolerably happy citizens. He was also a philanthropist, public benefactor and the founder of what may have been the first public school system.

Thompson is better known by the title he acquired in mid-career: Count Rumford. Among physicists the name Rumford is usually remembered, if at all, for the cannon-boring experiment. Although Rumford's most important contributions are largely forgotten, that particular accomplishment is frequently awarded more credit than it deserves. Rumford demonstrated that heat flow from a body is inexhaustible. Understanding neither the nature of heat nor the conservation of energy, he merely employed his experiment to discredit the caloric theory.



Count Rumford in 1797 at the age of 44. In 1796 he provided handsome endowments to the Royal Society in London and the American Academy of Arts and Sciences in Boston for prizes for research in heat and light. The Rumford prizes continue to be awarded today. Shortly thereafter he saved Munich from destruction by the French and Austrian armies, which were about to devastate the city in order to attack each other. By rushing from one commander to the other he managed to stall the attack long enough for the French to become distracted. Through this exercise of shuttle diplomacy he became the hero of Bavaria.

This achievement eventually turned out to be a source of great personal satisfaction. The chief architect of the caloric theory had been Lavoisier. Late in life, Rumford married Lavoisier's widow. The couple were totally incompatible, and when the marriage went bad Rumford taunted her with the deficiencies in his predecessor's theory.

Rumford's career was a roller coaster of ups and downs. While "down," he was either poor or under a stigma. Such was the case from his birth in 1752 until 1772, when he quit his job as a clerk in Boston to become a schoolmaster in Concord, New Hampshire. He was down again in 1775, when he abandoned his wife, child and the wealthiest estate in New Hampshire to avoid being tarred and feathered; in 1782, when he resigned his high position in the British government—Under Secretary of State for the Northern Department—and fled from London under suspicion of spying for the French; in 1783, when he abandoned his personal troop, the King's American Dragoons, to wander through Europe; in 1795, when he was forced to flee from Munich, where he was chamberlain and principal confidant to His Most Serene Electoral Highness Carl Theodor, Protector of Bavaria; and in 1802, when he had to resign his position as director of the Royal Institution and quit London.

While "up," Rumford was wealthy or a social lion, sometimes both. He went from down to up in 1772, when he became an instant gentleman by marrying the widow of the richest landowner in New Hampshire; in 1776, in London, when he became secretary and bosom companion of

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Lord George Germaine, Secretary of State for the Colonies; in 1785, when he became Carl Theodor's adjutant general and the second most powerful person in Bavaria; in 1800, when he personally raised a public subscription in London and founded the Royal Institution; and in 1805, when he married Madame Lavoisier, among whose charms was her considerable fortune. Rumford died in 1814 neither in rags nor in riches but in comfortable seclusion.

London at the end of the 18th century was often hellish. The pall of smoke from thousands of open fireplaces could turn day into night. Rumford analyzed this environmental crisis from two points of view: aesthetics and energy efficiency. The dense smoke carried off tons of unburned fuel. Rumford concluded that the fireplaces smoked primarily because of turbulence in the flue as cold and hot air mixed. Employing his knowledge of convective heat flow, which he had discovered, Rumford found out how to avoid turbulence. He introduced the damper to regulate the flow of hot air into the chimney, and the smoke shelf to let descending cold air mix smoothly with ascending hot air. The result was a stationary counterflow pattern in the chimney. Rumford determined that most of the heating from the fireplace came from radiation and that a shallow fireplace with a beveled back, preferably covered with soot, is an efficient radiator. His fireplace design remains the standard today.

Rumford personally supervised the rebuilding of fireplaces in the most fashionable homes in London, going to some lengths to seal leaks around doors and windows so as to form a relatively airtight enclosure. He made no profit but he became one of the most popular figures in town.

Rumford's most productive years were spent in Munich. Upon fleeing England in 1783 he wandered there armed only with a letter of introduction picked up during his journey. The social conditions in Bavaria were appalling, even by contemporary standards. There was a sizable population of beggars and criminals, and the army was in disarray. Rumford quickly rose to the rank of adjutant general and set about reforming army life.

In the 18th century a soldier's greatest misery was cold, particularly while on duty. Rumford went to work to develop a better army uniform. He investigated the thermal conductivity of materials and discovered that insulating power comes primarily from entrapped air. From this he concluded that layered thin material would be warmer than the thick material then in style. Furthermore, clothing of this design would be cheaper than the conventional uniforms. So his first step was to supply the army with energy-efficient uniforms.

The soldier's next problem was food, particularly cooking it. At the time, soldiers cooked their own meals in small groups using pots suspended over open fires. Rumford invented a field stove with an enclosed fire, which he then developed into an indoor stove with regulated air intake and exhaust. This became the kitchen range. Rumford analyzed the energy efficiency of cooking for various numbers of people and found that the larger the number, the more efficient the production. Every college student is in his debt, for it was Rumford who invented the modern dining hall, steamtable and all. He dabbled in nutrition and formulated the recipe for a nutritious soup that not only became the staple of European armies in the 19th century but was frequently served in the homes of Europe. Rumford soup can still be obtained in Munich.

Rumford next turned his attention to Munich's population of beggars and thieves—inner-city problems, as we call them today. The prevailing view was that such people suffer because their characters are weak and that to improve their lives one should first improve their characters. This issue, in one guise or another, is being debated today, but Rumford's ideas were definite: "To make vicious and abandoned people happy, it has generally been supposed necessary, *first,* to make them virtuous. But why not reverse this order! Why not make them first *happy,* and then virtuous!" He went on to point out that the end result is the same and that it is easier to start by solving material problems than by reforming morals.

Rumford implemented these ideas to solve the beggar problem. He devised a plan to give the beggars decent jobs with decent working conditions. When the time was right, he had the police round them up. He placed them in workhouses that were meticulously planned according to his ideas of maximum efficiency: good lighting, heating and food. The beggars' lot improved immeasurably, while Rumford made a personal fortune, for the product of the workhouses was clothing—specifically, army uniforms.

Beggars learned their trade from their parents, who frequently maimed their children to make them more pitiful. Rumford recognized that the problem of beggary could be solved permanently only if the cycle were broken at the family level. He had the children brought to the workhouses but cannily forbade them from working. There was little else to do, and soon the children were clamoring to work next to their parents. Rumford relented, but with the stipulation that the children spend several hours a day in the classroom. The teaching was free. What Rumford had done was to start a public school system. Whether or not this marked the creation of public education is not clear, but it was a major innovation that altered the public view of education.

To cite one last event in Rumford's long and picaresque career, in 1798 he had to flee Munich for the final time and ended up in London, more or less penniless. By this time he had accumulated a large body of knowlege on heating, lighting, cooking and other domestic technologies. His ideas were described voluminously in scientific papers and personal essays, but he understood that the artisans who needed the new knowledge would not get it by reading. Rumford's solution was to build an institution for exhibiting modern technology and teaching it to artisans. He set out to raise money for his project by public subscription from his many well-connected friends. The King contributed, and it was named the Royal Institution. From the first, however, Rumford ran into problems. The subscribers wanted the institution to teach them new science, which was immensely popular, while Rumford wanted it to serve the needs of artisans. The subscribers won out. Rumford choose Humphrey Davy as lecturer, and a few years later Davy chose Michael Faraday as his assistant. The Royal Institution flourishes today, though Rumford's attempt at technology transfer failed. One could argue that England's great scientific tradition was purchased at some cost to its domestic comforts.

Why is someone who did so much for science and society so little known? Possibly the reason is that in spite of his many virtues, Thompson suffered from some character defects. He was an unprincipled opportunist, a ruthless self-promoter and overbearingly arrogant. He had hardly any friends, and upon his death he was promptly forgotten.

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I am in debt to the late Sanborn C. Brown for introducing me to the life of Rumford. This essay is based on conversations with him and material in his scholarly and entertaining biography Benjamin Thompson, Count Rumford *(MIT P., Cambridge, Mass., 1979).* ■